

## CLAIMS:

1. A method for embedding watermarks in a digital host signal carrying signal information, the method comprising the steps of:  
generating a watermark sequence of length  $Lw/N$  bits carrying predetermined information;  
5 up-sampling the watermark sequence by a factor of  $N$ ;  
at the intermediate sampling points of the up-sampled sequence inserting a modified version of the watermark sequence to form a compound watermark sequence of length  $Lw$ ; and  
combining the compound watermark sequence with the host signal to  
10 watermark the host signal.
2. The method of claim 1, wherein  $N$  is 2.
3. The method of claim 1 or 2, wherein the modified versions of the watermark  
15 sequence are arranged such that the compound watermark sequence is bi-polar.
4. The method of claim 1, 2 or 3, wherein the modification for generating the modified versions is chosen such that the DC component of the compound watermark sequence is reduced or minimised.  
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5. The method of any preceding claim, wherein inserting the modified version of the watermark sequence comprises inserting a negative version of the said watermark sequence at intermediate sampling points so as to form a bipolar up-sampled sequence.
- 25 6. The method of any of the preceding claims, wherein inserting the modified versions comprises, for each intermediate point of the up-sampled watermark sequence, inserting a negative version of a neighbouring sampled value of the watermark sequence.

7. The method of any preceding claim, wherein the method for embedding of a watermark in the sequence comprises a transform domain coefficients modulating method.
8. Method as in claim 7, where the transform is FFT.
- 5 9. A watermark decoding method comprising the steps of:  
receiving a watermarked host signal;  
detecting a compound watermark sequence within the watermarked host  
signal;  
10 splitting the compound watermark sequence into at least two groups of sample  
values corresponding to a watermark sequence and a modified version of the watermark  
sequence; and  
performing inverse modification of the watermarked sequence in order to  
retrieve predetermined information carried by it.
- 15 10. The method of claim 9, wherein detecting the compound watermark sequence  
within the watermarked host signal comprises computing absolute values of received  
transform domain coefficients and performing a smoothing operation on them.
- 20 11. The method of claim 10, wherein the smoothing operation comprises  
averaging the computed absolute values to form an averaged transform domain signal.
12. The method of any of claims 9 to 11 , wherein the compound watermark  
sequence comprises transform domain coefficients and the step of splitting comprises  
25 splitting the transform domain coefficients to assemble a first sequence comprising  
information at odd sampling points within the compound watermark sequence, and a second  
sequence comprising information at even sampling points within the compound watermark  
sequence.
- 30 13. The method of claim 9, wherein the step of splitting comprises applying the  
averaged transform domain signal to first and second signal paths, each signal path  
comprising a factor 2 down sampler and one signal path being delayed with respect to the  
other so as to split the averaged transform domain signal into the first and second sequences.

14. The method of claim 9, wherein performing the inverse modification of the watermark sequence comprises taking the difference between the corresponding sample values of the first and second sequence and normalizing with respect to the sum of corresponding sample values of the first and second sequence.
- 5 15. A watermarked host signal, wherein the watermark comprises a compound watermark comprising a combination of an up-sampled sequence of a watermark and a modified version of the same watermark..
- 10 16. The watermarked host signal of claim 15, wherein the modification is chosen so as to reduce or minimise a DC component of the compound watermark.
17. The watermarked host signal of claim 15 or 16, wherein the compound watermark is generated by up-sampling the watermark and inserting the modified version of  
15 the watermark at the intermediate sampling points generated by the up-sampling.
18. The watermarked host signal of claim 15, 16 or 17, wherein where an up-sampling factor is chosen to be 2, the modified version comprises the inverse of the watermark  
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19. An apparatus for embedding watermarks in a digital host signal carrying signal information, the apparatus comprising:  
a watermark sequence generator (110) for generating a watermark sequence,  
an up-sampler (120) for up-sampling the watermark sequence by a factor of N;  
25 means for generating a compound watermark sequence by inserting a modified version of the watermark sequence into intermediate sampling points created by the up-sampling process; and  
an embedder (140) for applying the compound watermark signal to a host  
signal.  
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20. The apparatus of claim 19, wherein the modification is chosen so as to reduce or minimise a DC component of the compound watermark.

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21. The apparatus of claim 19 or 20, wherein the up-sampler comprises a two times up-sampler.
22. The apparatus of claim 20, wherein the means for forming a compound  
5 watermark comprises an FIR filter with a response  $B[m]=[-1,1]$ .
23. The apparatus of claim 19, 20, 21 or 22, wherein the watermark sequence comprises an FFT block.
- 10 24. A watermark decoding apparatus, the apparatus comprising:  
means for receiving a watermarked host signal;  
means for detecting a compound watermark sequence within the watermarked  
host signal;  
means for splitting the compound watermark sequence into at least first and  
15 second sequences corresponding to a watermark sequence and a modified version of the  
watermark sequence; and  
inverse modification means for performing an inverse modification of the  
watermark sequence in order to retrieve predetermined information carried by it.
- 20 25. The apparatus of claim 24, wherein the means for detecting a compound  
watermark sequence within the watermarked host signal comprises a filter (210) for  
separating out FFT coefficients of the compound watermark sequence from a received  
watermarked host signal.
- 25 26. The apparatus of claim 24 or 25, wherein the means for detecting the  
compound watermark sequence comprises absolute value computation means for providing  
absolute values of FFT coefficients.
27. The apparatus of claim 24, 25 or 26, wherein the means for detecting the  
30 compound watermark sequence comprises smoothing means for averaging the computed  
absolute values.
28. The apparatus of claim 27, wherein the smoothing means comprises an  
accumulator (220).

29. The apparatus of any of claims 24 to 28, wherein the means for splitting the compound watermark sequence comprise first and second signal processing means, the first signal processing means being provided in a first signal path and the second signal processing means being provided in a second signal path, each signal processing means comprising a down-sampler (240,250) of factor N and one of the first or second signal processing means further comprising delay means (230) so as to split the averaged transform domain signal into the first and second sequences.
- 10 30. The apparatus of any of claims 24 to 29, wherein the means for performing the inverse modification of the watermark sequence comprises modification means arranged to take the difference between corresponding sample values of the first and second sequence and normalise with respect to the sum of corresponding sample values of the first and second sequence.